

# Deploying Purpose-Grown Energy Crops for Sustainable Aviation Fuel Workshop

Dana Mitchell, Technology Manager

Alexander Jansen, Technology Manager

June 6-7, 2023



Feedstock



Algae



Conversion



Systems



Data



# Welcome from the Renewable Carbon Resources Program at BETO!



**Nichole Fitzgerald**  
Program Manager



**Mark Elless**  
Technology Manager



**Dan Fishman**  
Technology Manager



**Christy Sterner**  
Technology Manager



**Chenlin Li**  
Technology Manager



**Liz Burrows**  
Technology Manager



**Alexander Jansen**  
Technology Manager



**Dana Mitchell**  
Technology Manager



**Annie Otwell**  
AAAS Fellow



**Phil Lee**  
Project Monitor



**Jamie Meadows**  
Project Monitor



**Ty Robinson**  
Business Support



**Andrew Zimmerman**  
Program Analyst



**Atilio de Frais**  
Project Monitor

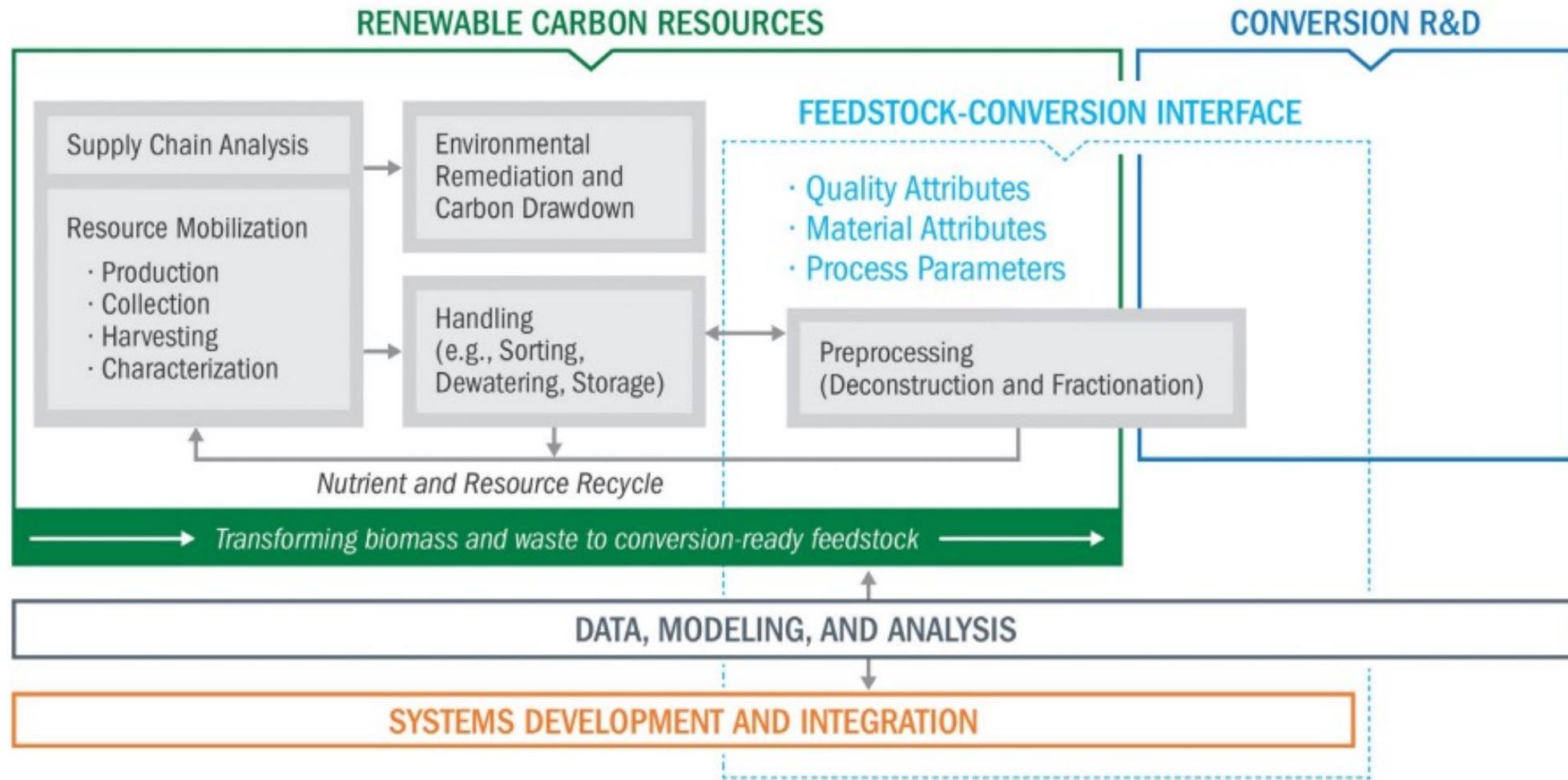


**Frank Fields**  
Project Monitor



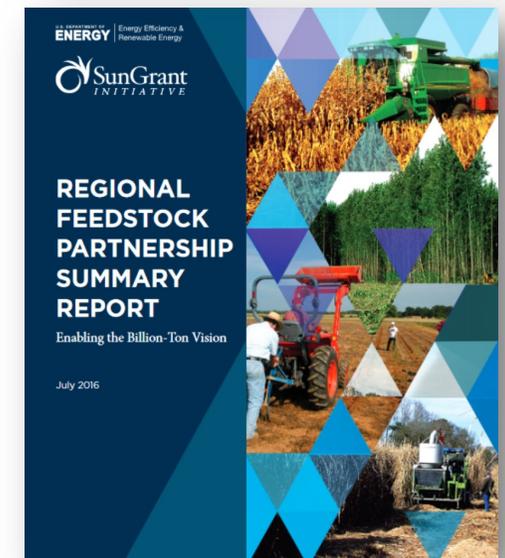
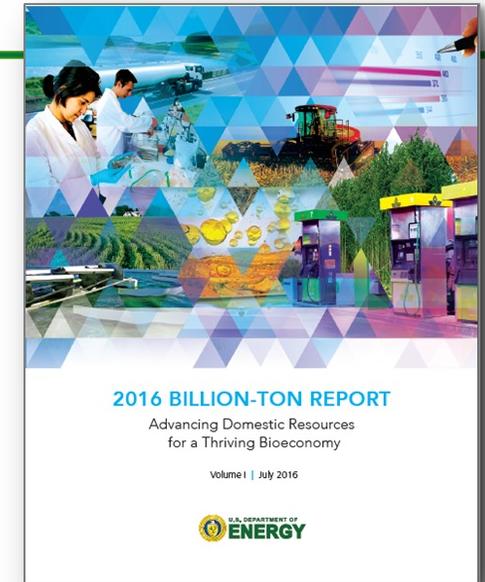
**Neil Watson**  
Business Support

# Where does our team fit in?



# Desired Workshop Outcomes

- Knowledge gaps to deploying purpose-grown energy crops and implementing climate-smart agricultural practices
- Develop potential strategies to overcome the knowledge gaps
- Identify innovative solutions in the collection of reliable, long-term growth data and specific sustainability metrics of success
- Establish and understand how to expand stakeholder networks in energy crops deployment



# Agenda – Day 1

Time	Agenda Item
9:00 – 10:30 am	Introductions/Opening Remarks
10:45 am – 12:15 pm	Promise of Purpose-Grown Energy Crops Panel Session
12:15 – 1:15 pm	Lunch
1:15 – 2:10 pm	Resource Considerations Presentations
2:25 – 3:35 pm	Breakout Session 1: Identifying Knowledge Gaps
3:35 – 4:45 pm	3x5 Presentation Session
4:45 – 5:00 pm	Closeout Day 1

## Day 1 Outcomes

- Overview of Workshop objectives
- Feedstock challenges and considerations from Panel and Invited Speakers
- Identify current knowledge gaps preventing deployment of purpose-grown energy crops

# Agenda – Day 2

Time	Agenda Item
9:00 – 9:15 am	Opening
9:15 – 10:25 am	Breakout Session 2: Ideas and Strategies for Addressing Knowledge Gaps
10:40 am – 12:00 pm	Breakout Session 3: Innovative Solutions for Successful Deployment
12:00 – 1:00 pm	Lunch
1:00 – 2:10 pm	3x5 Presentation Session
2:25 – 3:30 pm	Expanding the Network for Energy Crop Deployment
3:30 – 4:00 pm	Closeout Day 2

## Day 2 Outcomes

- Develop potential strategies to fill the knowledge gaps identified on Day 1
- Identify innovative solutions for deployment of energy crops
- Expand current stakeholder networks by region and feedstock type

# Safety & Housekeeping Minute

- Emergency Exits
- Outside Emergency Gathering Area
- First Aid Kits (Front Desk and Kitchen)
- Bathrooms
- Storm Shelter Area (Ballroom)
- For Embassy Suites Overnight Guests
  - Breakfast Hours: 6:30 – 9:30 am
  - Evening Reception 5:30 – 7:00 pm
- Workshop Provided Meals
  - Continental Breakfast
  - Lunch

## Wi-Fi: Hilton Honors

**\*click Promotional Code at bottom of screen\***

**Password: MKCPD**



# Overview of Workshop Purpose and Progress

- Michael Berube, Deputy Assistant Director of Sustainable Transportation, DOE
- Kevin Kephart, Deputy Director, Institute of Bioenergy, Climate and Environment, National Institute of Food and Agriculture, USDA
- Vance Owens, National Program Leader, Division of Plant Systems – Production, National Institute of Food and Agriculture, USDA



Virtual Q&A



# DOE - BETO Perspective

Dana Mitchell, Technology Manager

Alexander Jansen, Technology Manager

June 6-7, 2023



Feedstock



Algae



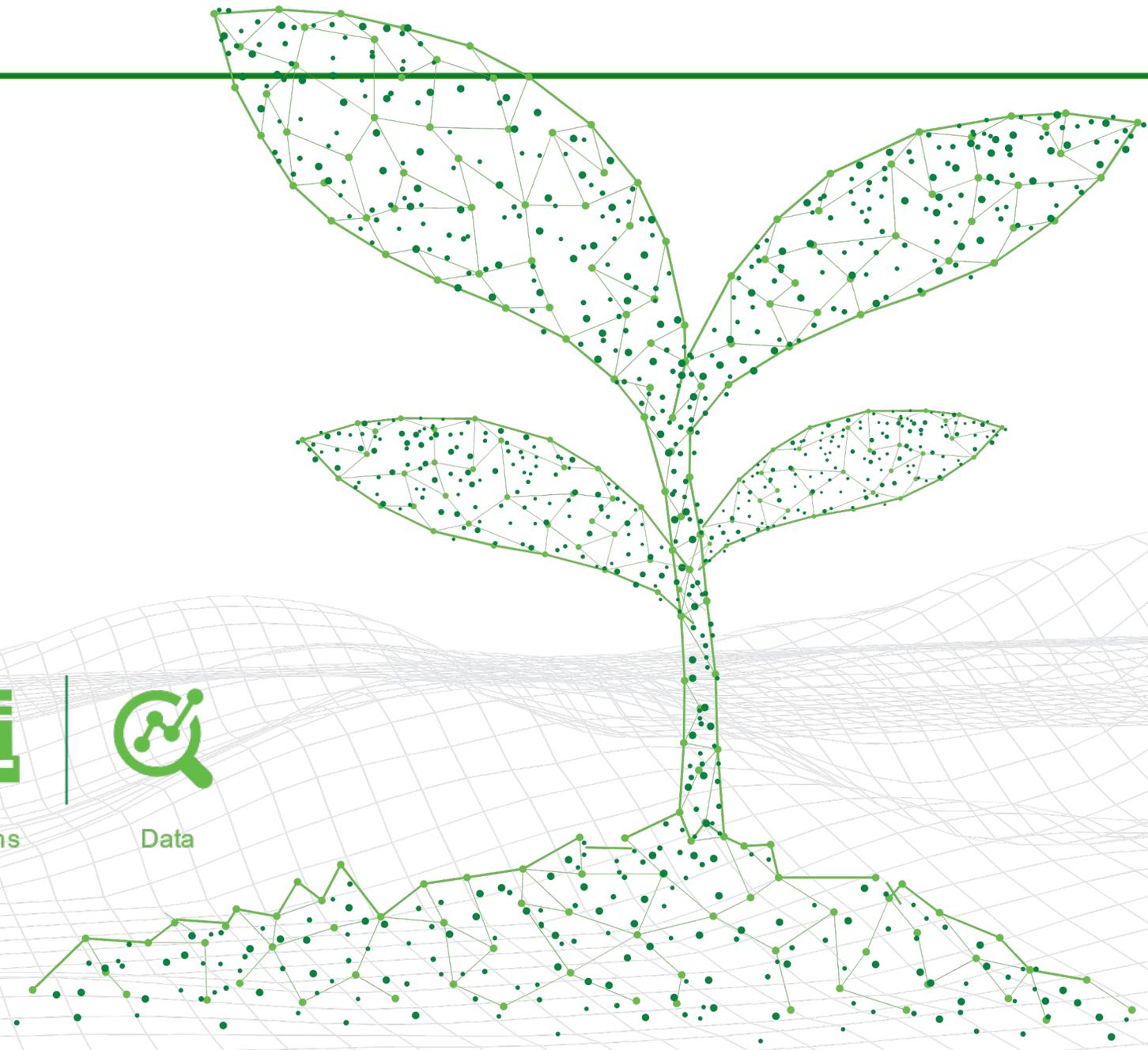
Conversion



Systems



Data

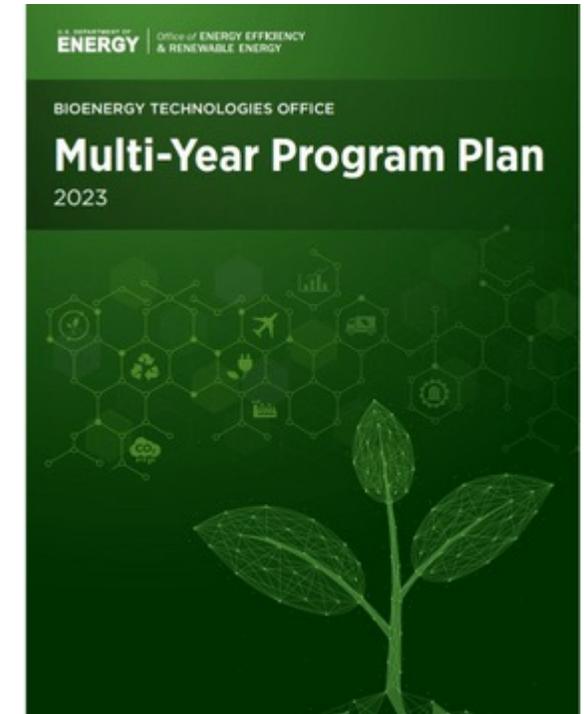


# BETO 2023 Multi-Year Program Plan

- **BETO RD&D strategies and crosscutting programmatic activities**

## BETO Strategic Goals

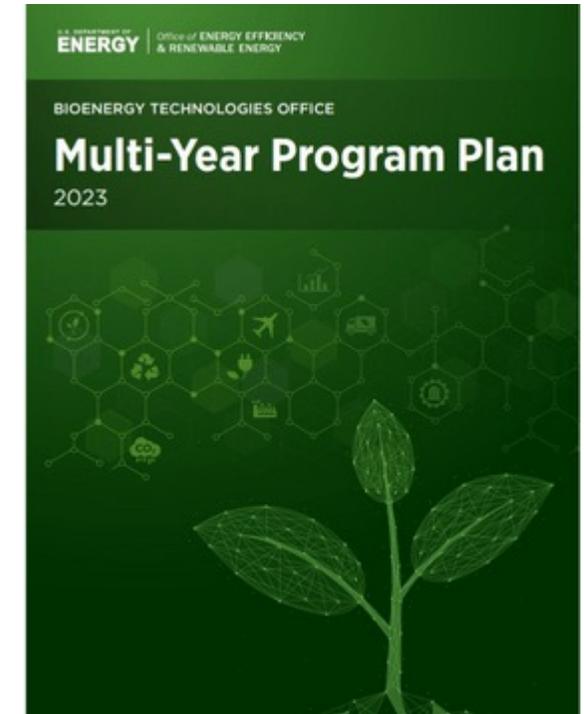
1. **Decarbonize the transportation sector through RD&D to produce cost-effective, sustainable aviation and other strategic fuels**
2. **Decarbonize the industrial sector through RD&D to produce cost-effective and sustainable chemicals, materials, and processes utilizing biomass and waste resources**
3. **Develop cost-effective, sustainable biomass and waste utilization technologies and innovative approaches contributing to the decarbonization of the agriculture sector...or other beneficial uses**



# BETO 2023 Multi-Year Program Plan

## BETO's Key Performance Goals

1. Enable delivery, preprocessing, and deconstruction of sufficient volumes of biomass and waste feedstocks to biofuel intermediates that can meet industry-relevant cost and performance requirements, with a focus on SAFs capable of >70% reduction in GHG emissions relative to petroleum
2. Along with industrial and federal partners, support 3 billions gallons of SAF production and use, consistent with a trajectory to ultimately producing 35 billion gallons by 2050
3. Demonstrate more than three place-based strategies for climate-smart agriculture, waste management, environmental remediation, or other beneficial uses of renewable carbon resources



# BETO 2023 Multi-Year Program Plan – RCR RD&D

## RCR Strategic Objective

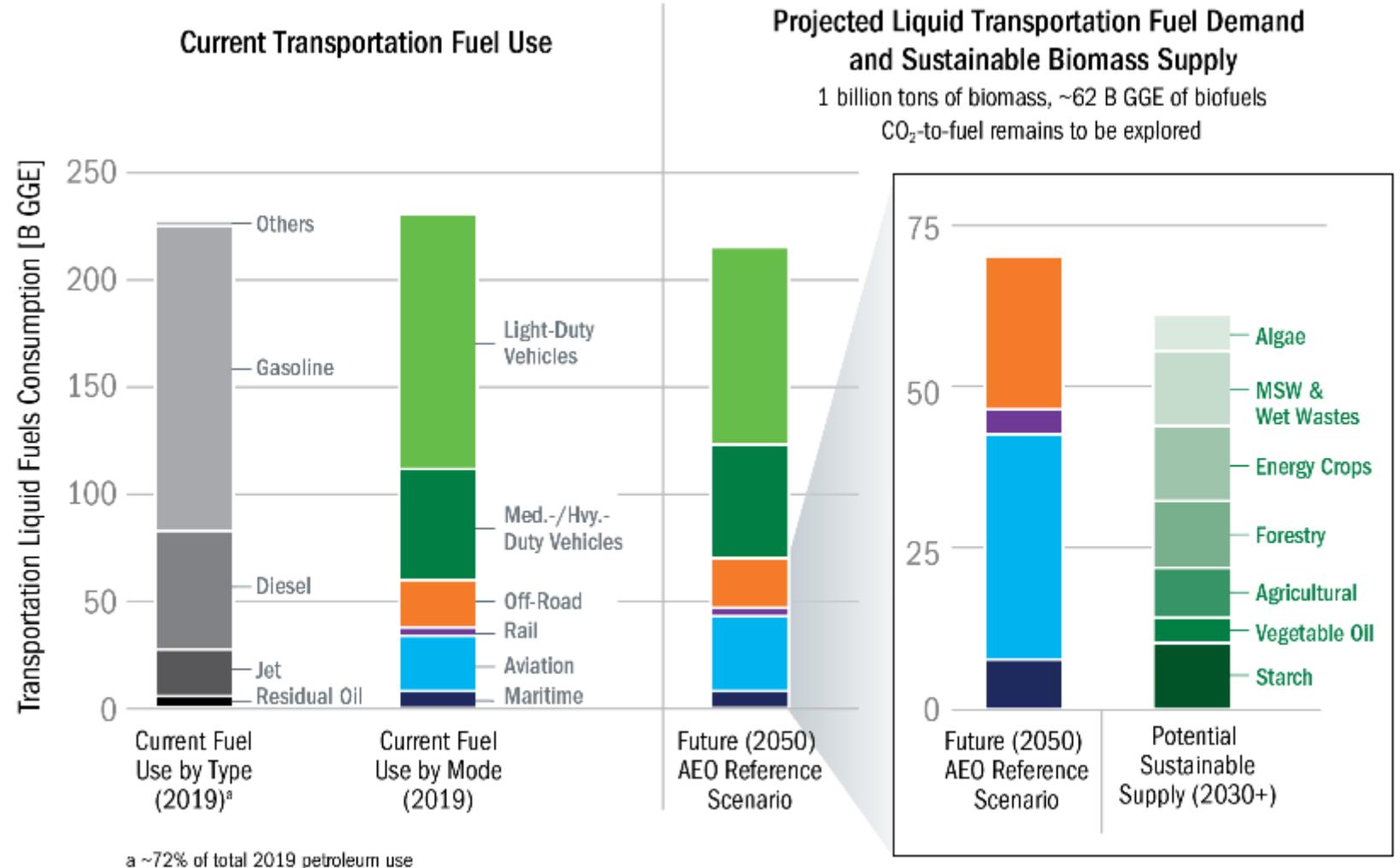
- To develop technologies to mobilize renewable carbon resources to enable the production of bioenergy and renewable chemicals and materials

## Resource Focuses

- Agricultural and forestry residues
- Waste streams (MSW, biosolids, sludges, etc.)
- Commodity crops
- Resources from ecosystem restoration or maintenance (fire mitigation, harmful algal blooms)
- Purpose-grown energy crops
  - Algae (microalgae, macroalgae, cyanobacteria)
  - Herbaceous crops (switchgrass, miscanthus, energy cane, sorghum)
  - Short-rotation woody crops (hybrid poplars, shrub willows)
  - Overwintering secondary crops (carinata, pennycress)

# Why are we interested in purpose-grown energy crops?

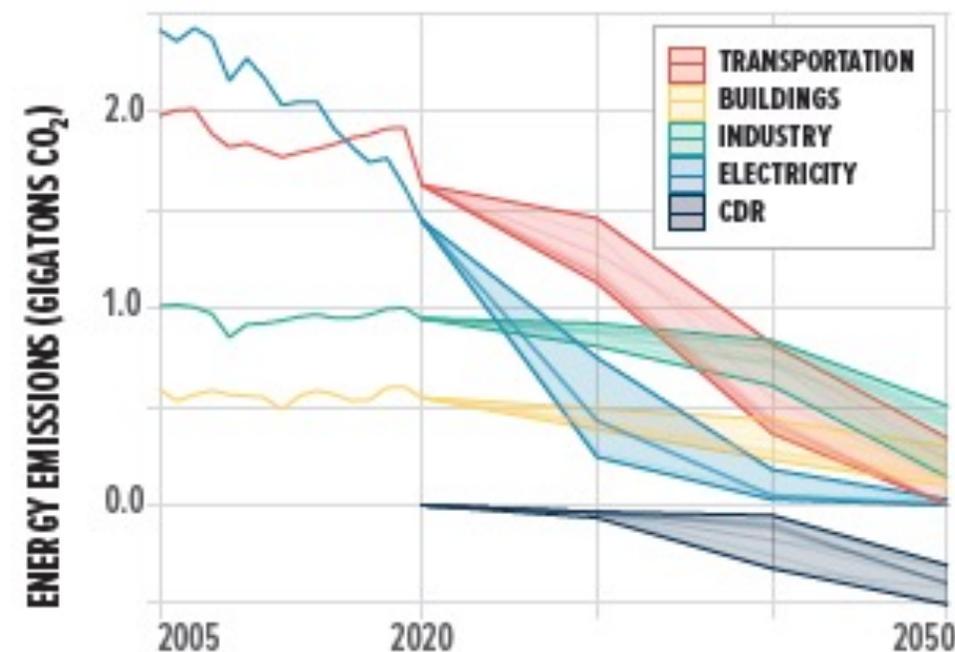
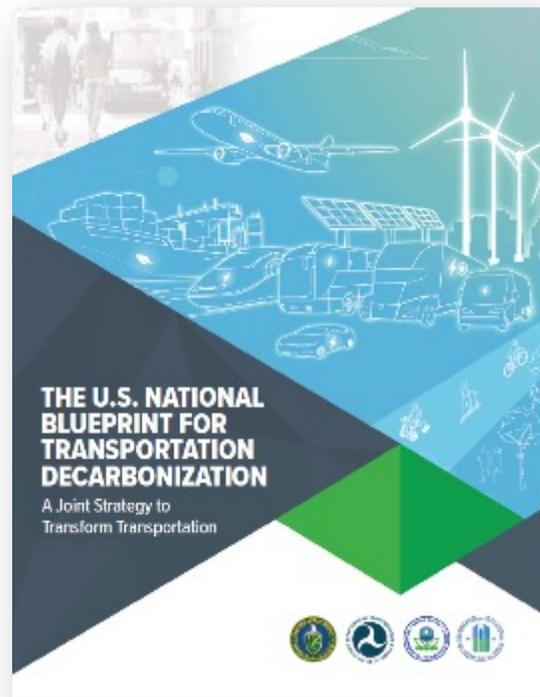
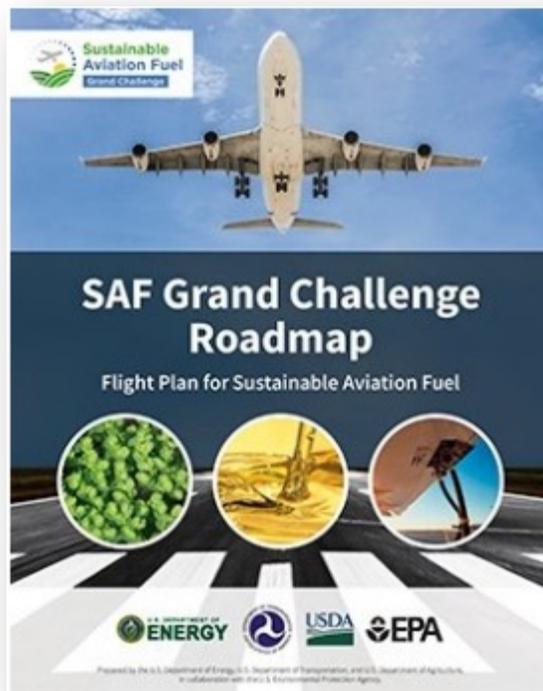
- Purpose-grown energy crops, including algae will be essential for achieving U.S. decarbonization goals
- What is needed to enable widespread energy crop deployment?



AEO = annual energy outlook | GGE = gasoline gallon equivalent | MSW = municipal solid waste

# Why are we interested in purpose-grown energy crops?

- The success of many government-wide decarbonization initiatives hinges on fuels that can be sustainably produced from purpose-grown energy crops



Source: *The Long-Term Strategy of the United States: Pathways to Net-Zero Greenhouse Gas Emissions by 2050*, Nov 2021

# Clean Fuels & Products Earthshot

- Announced May 24<sup>th</sup>, this Shot focuses on decarbonizing the fuel and chemical industry through alternative sources of carbon to advance cost-effective technologies with a minimum of 85% lower GHG emissions by 2035

 Mobilize Renewable Carbon Resources

**Expand and Develop New Feedstocks:**  
Develop and utilize new technologies to maximize carbon incorporation and retention to generate low-cost, low-emissions biomass, waste, and CO<sub>2</sub> feedstocks at scale

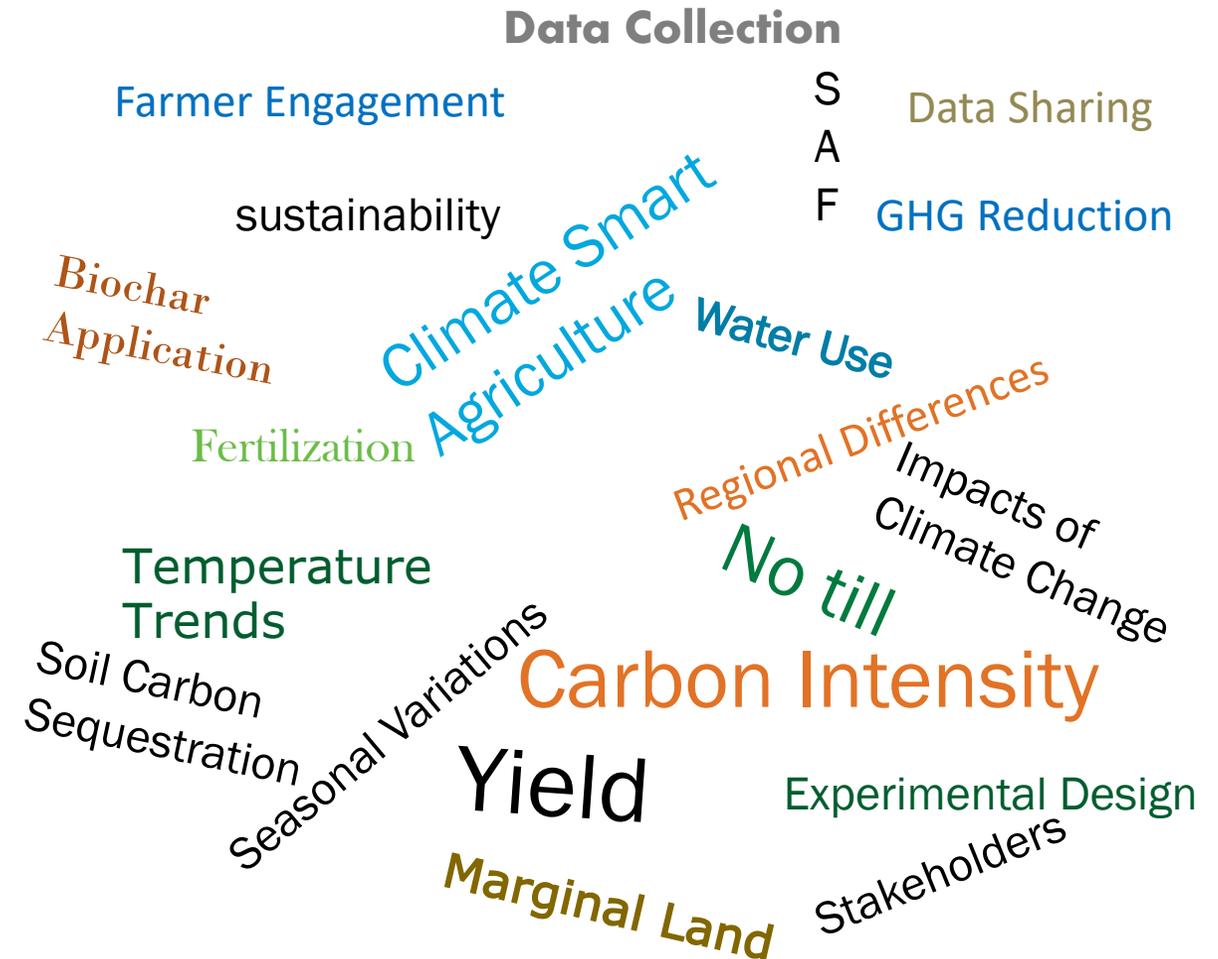
**Examples:**  
Forest residues, agricultural wastes, municipal solid waste, recycled materials, energy crops, algae, CO<sub>2</sub>



# Moving Beyond the Regional Feedstock Partnership

What are we missing?

- Technical Needs
- Market and Policy Needs
- Data Needs
- Land Use Needs



# Opening Networking

- **PAIR UP AND ASK YOUR PARTNER**
  - Who are you and what is your job?
  - What prompted you to attend this event?
  - What are you hoping to learn?
- **JOIN ANOTHER PAIR**
  - Share highlights of what you learned about your partner.
- **CROSS PARTNERS AND JOIN A DIFFERENT PAIR**
  - Share one thing about any purpose grown energy crops work that you've been involved with (past).
  - Share something you are planning or looking forward to (future).

# Break Countdown Timer

---



15:00

# Panel Q&A

- Notecards at your table



Wi-Fi: Hilton Honors Meetings  
Password: MKCPD

- Workshop Q&A site



# Panelist Introductions



**Dr. Matthew Langholtz**



**Dr. Sam Jackson**



**Dr. Emily Heaton**



**Dr. Kimberly Ogden**

# Lunch Timer



# Agenda – Day 1

Time	Agenda Item
9:00 – 10:30 am	Introductions/Opening Remarks
12:15 – 1:15 pm	Lunch
1:15 – 2:10 pm	Resource Considerations Presentations
2:25 – 3:35 pm	Breakout Session 1: Identifying Knowledge Gaps
3:35 – 4:45 pm	3x5 Presentation Session
4:45 – 5:00 pm	Closeout Day 1

## Day 1 Outcomes

- ✓ **Overview of Workshop objectives**
  - **Feedstock challenges and considerations from Panel and Invited Speakers**
  - **Identify current knowledge gaps preventing deployment of purpose-grown energy crops**

# Resource Considerations Introductions



**Bill Belden**



**Dr. John McGowan**



**Rachel Emerson**

**Virtual Q&A**



# Breakout instructions

## Process

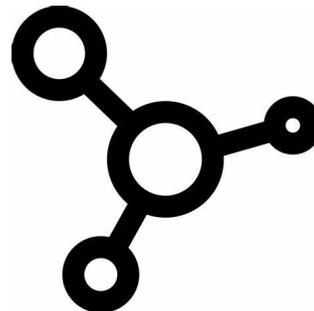
- Discuss needs while note-taker documents on screen
- Last 10 minutes, group decides **Top 5 Knowledge Gaps/Needs** for report-out slide

## Norms

Three before Me



Synthesize



Include



Algae (A)		Herbaceous (D)			Woody (B)		Secondary (C)	
John		Brian					Ana Paula	
Louis Brown	McGowen	Baldwin	D.K. Lee	William Smith	Zia Abdullah	Tim Rials	Alonso	Anjli Kumar
Michael	Jamie	William			Nicholas			Xinyu Liu
Burkart	Meadows	Belden	Uisung Lee	Meron Tesfaye	Carpita	Susan Rupp	Zoe Amerigian	Kari Perez
Damian	Brian	Richard	Wayne	Babu			Onofre	
Carrieri	Mitchell	Brunner	McFarland	Valliyodan	Sean Carr	Parag Shah	Andrade	Matt Luetje
Alina	Emily				Rachel			Daniel
Corcoran	Newes	Brutus Clay	John McKay	Guojie Wang	Emerson	Tim Theiss	Chad Asmus	Santosa
	Kimberly	Chuck			Damon	Meltem Urgun-		Beth
Taraka Dale	Ogden	Coronella	Jesse Morrison	Keith Webster	Hartley	Demirtas	Sharon Bard	Stukenholtz
Scott	Braxton	Steve				Claudia	Barney	
Edmundson	Salcedo	Croxton	Nictor Namoi	Lloyd Wilson	Richard Hess	Valderrama	Bernstein	Ty Stukenholtz
David	Claire	Richard			Matthew			
Hazlebeck	Sanders	Harris	Erin Nuccio	Yan Zhang	Langholtz	Timothy Volk	Mary Bidy	Virginia Sykes
Umakanta	Paul	Emily			Jessica		Lokendra	
Jena	Simpson	Heaton	Vance Owens	Colleen Zumpf	McCord	Erin Webb	Chauhan	T. Edward Yu
Zackary	Christy	Sam			James			
Johnson	Sterner	Jackson	Wendy Owens	John Mullet	McManus	Paul Wever	Doug Collins	J. Alan Weber
	Peter	Kevin						
Jon Kallen	Valdez	Kephart	Bin Peng		Mike Peach	Bethany Wright	Ryan Davis	Scott Nuseed
Lieve	Bradley	Nicole	Reyhaneh		Darren		Justin	Arivalagan
Laurens	Wahlen	Labbe	Shenassa		Peterson	Fred Circle	Eisenach	Kaliannan
Jay	Lynn	Philip	Craig		Heidi	Corinne	Meytal	Vanessa
	Endt	Laible	Simmons		Renninger	Drennan	Higgins	Elliot

# Break Timer

---

A digital timer display with a black background and white text. The time shown is 15:00. The display is centered on the page.

**15:00**

# Report outs

---

# 3x5 Overview

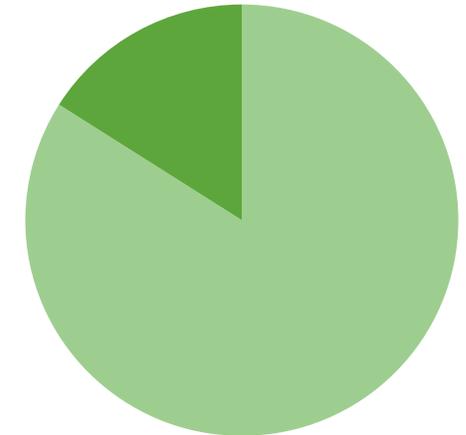
- Speakers will have 5 minutes to present 3 slides
- No Q&A

Wendy Owens	Hexas Biomass
David Hazlebeck	Global Algae Innovations
Lokendra Pratap Singh Chauhan	Qen Labs Inc.
Collen Zumpf	Argonne National Lab
Keith Webster	Iowa State University
Tim Volk	SUNY ESF
Greg Mitchell	University of California: San Diego
Anjli Kumar	Technology Holding
Bin Peng	University of Illinois at Urbana-Champaign
Xinyu Liu	Argonne National Lab

# Day 1 Review

Time	Agenda Item
9:00 – 10:30 am	Introductions/Opening Remarks
12:15 – 1:15 pm	Lunch
1:15 – 2:10 pm	Resource Considerations Presentations
2:25 – 3:35 pm	Breakout Session 1: Identifying Knowledge Gaps
3:35 – 4:45 pm	3x5 Presentation Session

■ Passive ■ Active



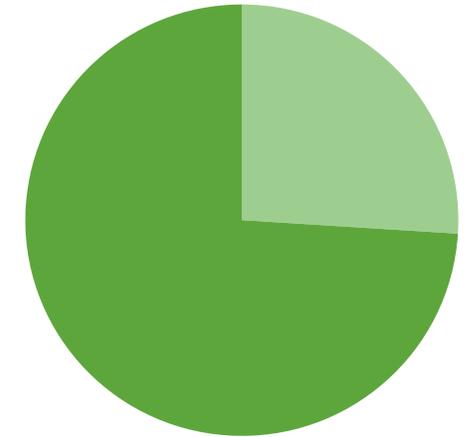
## Day 1 Outcomes

- ✓ Overview of Workshop objectives
- ✓ Feedstock challenges and considerations from Panel and Invited Speakers
- ✓ Identify current knowledge gaps preventing deployment of purpose-grown energy crops

# Agenda – Day 2

Time	Agenda Item
9:00 – 9:15 am	Opening
9:15 – 10:25 am	Breakout Session 2: Ideas and Strategies for Addressing Knowledge Gaps
10:40 am – 12:00 pm	Breakout Session 3: Innovative Solutions for Successful Deployment
12:00 – 1:00 pm	Lunch
1:00 – 2:10 pm	3x5 Presentation Session
2:25 – 3:30 pm	Expanding the Network for Energy Crop Deployment
3:30 – 4:00 pm	Closeout Day 2

■ Passive ■ Active



## Day 2 Outcomes

- Develop potential strategies to fill the knowledge gaps identified on Day 1
- Identify innovative solutions for deployment of energy crops
- Expand current stakeholder networks by region and feedstock type

# Deploying Purpose-Grown Energy Crops for Sustainable Aviation Fuel Workshop

Dana Mitchell, Technology Manager

Alexander Jansen, Technology Manager

June 6-7, 2023



Feedstock



Algae



Conversion



Systems



Data



# Safety & Housekeeping Minute

- Emergency Exits
- Outside Emergency Gathering Area
- First Aid Kits (Front Desk and Kitchen)
- Bathrooms
- Storm Shelter Area (Ballroom)
- For Embassy Suites Overnight Guests
  - Breakfast Hours: 6:30 – 9:30 am
  - Evening Reception 5:30 – 7:00 pm
- Workshop Provided Meals
  - Continental Breakfast
  - Lunch

## Wi-Fi: Hilton Honors

**\*click Promotional Code at bottom of screen\***

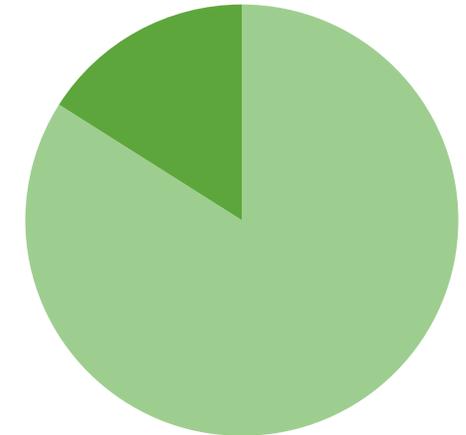
**Password: MKCPD**



# Day 1 Review

Time	Agenda Item
9:00 – 10:30 am	Introductions/Opening Remarks
10:45 am – 12:15 pm	Promise of Purpose-Grown Energy Crops Panel Session
12:15 – 1:15 pm	Lunch
1:15 – 2:10 pm	Resource Considerations Presentations
2:25 – 3:35 pm	Breakout Session 1: Identifying Knowledge Gaps
3:35 – 4:45 pm	3x5 Presentation Session
4:45 – 5:00 pm	Closeout Day 1

■ Passive ■ Active



## Day 1 Outcomes

- ✓ Overview of Workshop objectives
- ✓ Feedstock challenges and considerations from Panel and Invited Speakers
- ✓ Identify current knowledge gaps preventing deployment of purpose-grown energy crops

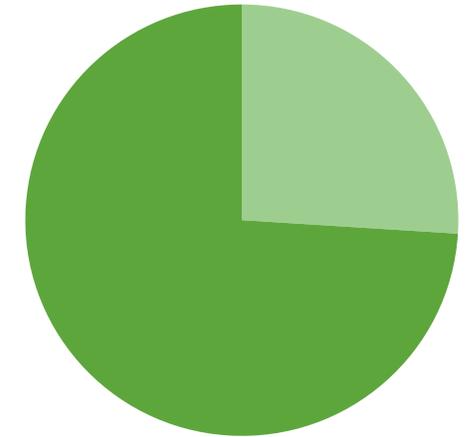
# Agenda – Day 2

Time	Agenda Item
9:00 – 9:15 am	Opening
9:15 – 10:25 am	Breakout Session 2: Ideas and Strategies for Addressing Knowledge Gaps
10:40 am – 12:00 pm	Breakout Session 3: Innovative Solutions for Successful Deployment
12:00 – 1:00 pm	Lunch
1:00 – 2:10 pm	3x5 Presentation Session
2:25 – 3:30 pm	Expanding the Network for Energy Crop Deployment
3:30 – 4:00 pm	Closeout Day 2

## Day 2 Outcomes

- Develop potential strategies to fill the knowledge gaps identified on Day 1
- Identify innovative solutions for deployment of energy crops
- Expand current stakeholder networks by region and feedstock type

■ Passive ■ Active



Virtual Q&A



# Day 2 Welcome

## Herbaceous

1. Long term risk
2. Market requirements
3. How to measure success
4. Standardized protocols
5. Understanding value chains

## Woody

1. Large scale studies
2. Preprocessing and logistics
3. Updated yield and quality
4. Soil characteristics
5. Human dimension

## Algae

1. Large scale
2. Long term
3. Fractionation and processing
4. Engineering models with process control
5. Consistent carbon accounting

## Secondary

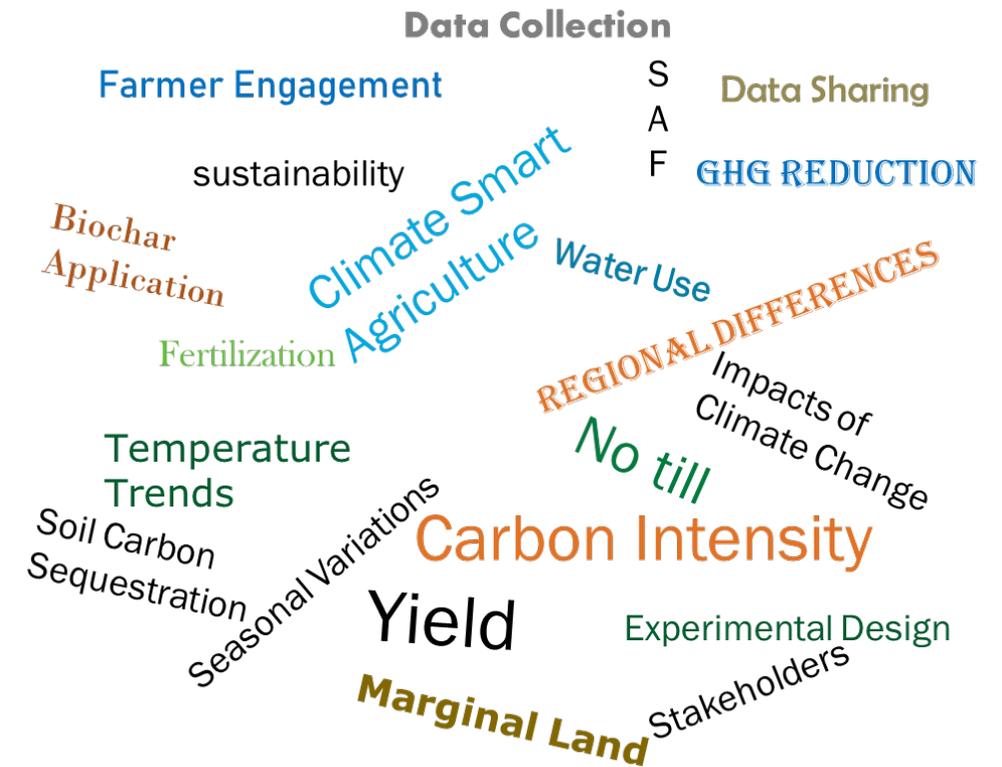
1. Market requirements
2. Regulatory barriers
3. What should be grown where
4. Consistent carbon accounting
5. Information sharing

# Breakout Session 2

- Process

- Discuss ideas and strategies to address top gaps identified Day 1
- For each of the top 5 knowledge gaps, what are the most promising applied R&D solutions?

- Large, high level ideas
- “We need to test...”
- “We should explore...”
- “We need to compare...”
- “We need data for...”

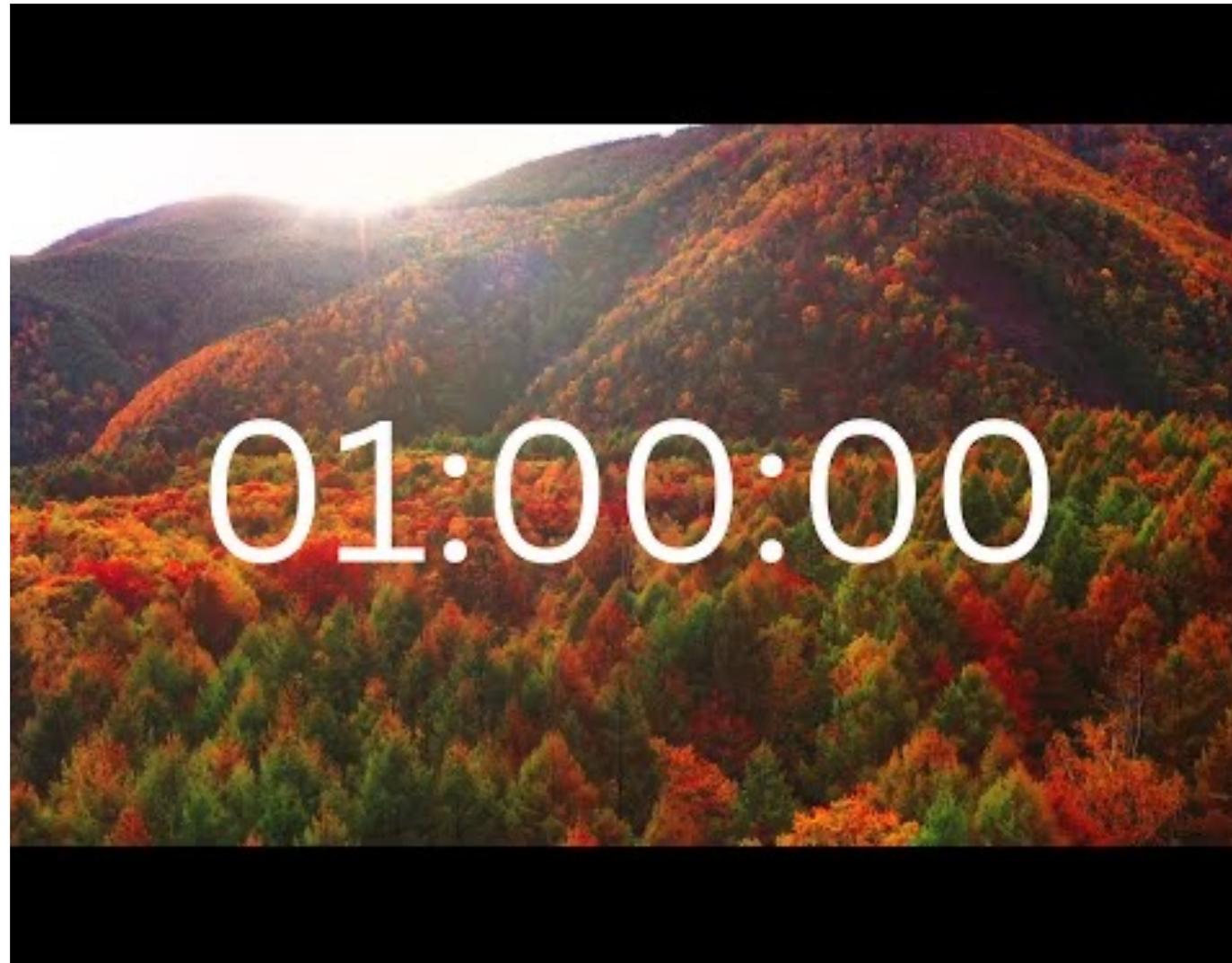


# Breakout Session 3

---

- Process
  - For each of solutions, what would these look like if implemented?
    - Looking for the “how” of the solutions proposed
    - “The metrics needed are...”
    - “What does the scope look like?”
    - “Where is the site?”
    - “What is the scale?”
    - “How is this managed?”

# Lunch Timer

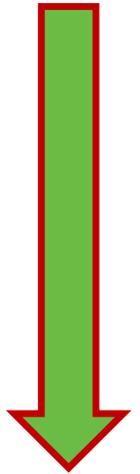


# Agenda – Day 2

Time	Agenda Item
9:00 – 9:15 am	Opening
9:15 – 10:25 am	Breakout Session 2: Ideas and Strategies for Addressing Knowledge Gaps
10:40 am – 12:00 pm	Breakout Session 3: Innovative Solutions for Successful Deployment
12:00 – 1:00 pm	Lunch
1:00 – 2:10 pm	3x5 Presentation Session
2:25 – 3:30 pm	Expanding the Network for Energy Crop Deployment
3:30 – 4:00 pm	Closeout Day 2

## Day 2 Outcomes

- ✓ Develop potential strategies to fill the knowledge gaps identified on Day 1
- ✓ Identify innovative solutions for deployment of energy crops
- Expand current stakeholder networks by region and feedstock type



**WORKSHOP  
EVALUATION**



# 3x5 Overview

- **Speakers will have 5 minutes to present 3 slides**
- **No Q&A**

Erin Webb	Oak Ridge National Lab
Barney Bernstein	Sustainable Oils, Inc.
Kimberly Ogden	University of Arizona
D.K. Lee	University of Illinois at Urbana-Champaign
Jay McCarren	Viridos
Lloyd Wilson	Texas A&M AgriLife Research
Virginia Sykes	University of Tennessee
Bill Belden	Antares Group Inc.
John McKay	New West Genetics
Ana Paula Alonso	University of North Texas

# Break Timer

---

A digital timer display with a black background and white text. The time shown is 15:00. The display is centered on the page.

**15:00**

# Mingling Discussion: Expanding Stakeholder Networks



## PART 1, REGIONAL FOCUS

“How could we establish/expand stakeholder networks in energy crop deployment for all feedstocks within each region?”

NE    SE    NPlains    SPlains    SW+CA    HI    PNW    MTN

## PART 2, FEEDSTOCK FOCUS

“How could we expand establish/expand stakeholder networks for deployment of this feedstock area in all regions?”

# Closing Remarks– Workshop Outcomes

- ✓ Identify knowledge gaps to deploying purpose-grown energy crops and implementing climate-smart agricultural practices
- ✓ Develop potential strategies to overcome the knowledge gaps
- ✓ Identify innovative solutions in the collection of reliable, long-term growth data and specific sustainability metrics of success
- ✓ Establish and understand how to expand stakeholder networks in energy crops deployment

HOW DID IT  
GO FOR YOU?



# Closing Remarks – Next Steps

---

## Sooner

- Post speaker presentations online
- Review workshop evaluations and any additional feedback in XLeap

## Later

- Post official workshop report online
- Inform future research portfolio

# Closing table conversations

---

## So What and Now What?

- How would you describe the "So What" from this workshop?
- Why was this conversation important, or why did it matter to you?

# Thank You!

Dana Mitchell

[Dana.Mitchell@ee.doe.gov](mailto:Dana.Mitchell@ee.doe.gov)

Alexander Jansen

[Alexander.Jansen@ee.doe.gov](mailto:Alexander.Jansen@ee.doe.gov)



Feedstock



Algae



Conversion



Systems



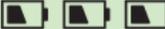
Data

WE WANT  
YOUR  
FEEDBACK



# Blueprint for Transportation Decarbonization

- Multiple Federal Organizations focused on a clear goal
  - DOE, DOT, EPA, HUD

	 <b>BATTERY/ELECTRIC</b>	 <b>HYDROGEN</b>	 <b>SUSTAINABLE LIQUID FUELS</b>
Light Duty Vehicles (49%)*		—	TBD
Medium, Short-Haul Heavy Trucks & Buses (~14%)			
Long-Haul Heavy Trucks (~7%)			
Off-road (10%)			
Rail (2%)			
Maritime (3%)		 †	
Aviation (11%)			
Pipelines (4%)		TBD	TBD
<b>Additional Opportunities</b>	<ul style="list-style-type: none"> <li>• Stationary battery use</li> <li>• Grid support (managed EV charging)</li> </ul>	<ul style="list-style-type: none"> <li>• Heavy industries</li> <li>• Grid support</li> <li>• Feedstock for chemicals and fuels</li> </ul>	<ul style="list-style-type: none"> <li>• Decarbonize plastics/chemicals</li> <li>• Bio-products</li> </ul>
<b>RD&amp;D Priorities</b>	<ul style="list-style-type: none"> <li>• National battery strategy</li> <li>• Charging infrastructure</li> <li>• Grid integration</li> <li>• Battery recycling</li> </ul>	<ul style="list-style-type: none"> <li>• Electrolyzer costs</li> <li>• Fuel cell durability and cost</li> <li>• Clean hydrogen infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>• Multiple cost-effective drop-in sustainable fuels</li> <li>• Reduce ethanol carbon intensity</li> <li>• Bioenergy scale-up</li> </ul>

\* All emissions shares are for 2019

† Includes hydrogen for ammonia and methanol

